Ancilla-Free Quantum Protocol for Thermal Green's Functions

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Abstract:

We introduce a simple and noise-resilient quantum algorithm for computing both zero- and finite-temperature Green's functions, requiring no ancillas and relying only on native time evolution and measurements readily available on current platforms. Exploiting parity symmetry — a condition satisfied by a broad class of Hamiltonians relevant to condensed matter physics and quantum chemistry, including the Fermi–Hubbard and Heisenberg models— we construct symmetric and antisymmetric thermal states and apply a tailored quench spectroscopy scheme to extract the exact real and imaginary parts of two-point time correlators (both fermionic correlators and bosonic correlators), from which Green's functions are efficiently reconstructed. The protocol is theoretically efficient, experimentally accessible, and directly applicable to both digital and analog quantum computers. Beyond Green's functions, the same framework extends naturally to out-of-time-order correlators (OTOCs). This work highlights a practical path toward probing finite-temperature dynamics of strongly correlated quantum systems on near-term and early fault-tolerant quantum hardware.